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RESEARCH ARTICLE

Changes in Hospital Inpatient Utilization Following Health Care Reform

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Objective. To estimate the effects of 2014 Medicaid expansions on inpatient outcomes.

Data Sources. Health Care Cost and Utilization Project State Inpatient Databases, 2011–2014; population and unemployment estimates.

Study Design. Retrospective study estimating effects of Medicaid expansions using difference-in-differences regression. Outcomes included total admissions, referral-sensitive surgical and preventable admissions, length of stay, cost, and patient illness severity.

Findings. In 2014 quarter four, compared with nonexpansion states, Medicaid admissions increased (28.5 percent, $p = .006$), and uninsured and private admissions decreased (–55.1 percent, $p = .001$, and –6.6 percent, $p = .052$), whereas all-payer admissions showed little change. Uninsured expansion effects were negative for preventable admissions (−24.4 percent, $p = .068$), length of stay (–9.3 percent, $p = .039$), total cost (−9.2 percent, $p = .128$), and illness severity (−4.5 percent, $p = .397$). Significant positive expansion effects were found for Medicaid referral-sensitive surgeries (11.8 percent, $p = .021$) and patient illness severity (2.3 percent, $p = .015$). Private and all-payer expansion effects for outcomes other than admission volume were small and mainly nonsignificant ($p > .05$).

Conclusion. Medicaid expansions did not change all-payer admission volumes, but they were associated with increased Medicaid and decreased uninsured volumes. Results suggest those previously uninsured with greater needs for inpatient services were most likely to gain coverage. Compositional changes in uninsured and Medicaid admissions may be due to selection.

Key Words. Affordable Care Act, Medicaid expansion, medically uninsured, inpatient care

Major health insurance coverage provisions of the Affordable Care Act (ACA) legislation went into effect in 2014, including Health Insurance Marketplaces for individuals to purchase subsidized private coverage and the option for states to expand Medicaid. As of March 2016, provisions of the ACA resulted in gains in health insurance coverage by 20 million people (Assistant Secretary for Planning and Evaluation 2016).

The primary objective of our study was to measure the impact of the ACA Medicaid expansion on adult utilization of inpatient hospital services. Some states implemented the ACA Medicaid expansion and others did not. This dichotomy provides a quasi-experimental framework for studying the impact of policy change on inpatient care, including admission volumes, preventable hospitalizations, patient illness severity, and cost of hospitalization.

Our study hypotheses are based on three mechanisms through which an expansion in health insurance coverage can affect contemporaneous inpatient utilization and patient behavior. First, health insurance lowers the out-of-pocket price to patients purchasing health care services and therefore increases use on average (Newhouse 1996). Second, health insurance can increase use of primary care, providing services in the outpatient setting that may reduce rates of ambulatory sensitive, or referral-sensitive hospital inpatient care (Billings et al. 1993; U.S. Agency for Healthcare Research and Quality 2001a, b, 2015c; Billings 2003; Buchmueller, Ham, and Shore-Sheppard 2015). Third, while limited evidence exists, we also posit that individuals without insurance who have the greatest medical care needs may be among the first to acquire insurance under the ACA coverage expansion (Blue Cross Blue Shield Association, 2016).

Compared with nonexpansion states, we hypothesize that expansion states will experience the following: (1) an increase in Medicaid and all-payer admission volumes and a decrease in uninsured admission volumes, (2) an increase in the proportion of referral-sensitive surgical admissions for Medicaid and all-payers, (3) a decrease in the proportion of preventable hospitalizations for Medicaid and all-payers; and (4) a decrease in cost per admission, length of stay, and patient illness severity for uninsured patients.

The effect of Medicaid expansion on the use of hospital care by the privately insured reflects two opposing factors. First, Health Insurance

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Marketplace enrollment should be associated with an increase in the volume of privately insured hospitalizations. However, Medicaid expansions may crowd out private insurance, resulting in fewer hospitalizations covered by private insurance. We thus consider the direction of this effect theoretically ambiguous.

BACKGROUND

Several studies have examined effects of individual state health care reforms on hospital utilization, insurance coverage, and treatment outcomes prior to passage of the ACA in Massachusetts, Connecticut, Wisconsin, Oregon, and California.

In the case of Massachusetts health care reform, studies found decreases in uninsured admissions and length of stay (Kolstad and Kowalski 2012), and increases in inpatient surgeries (Ellimoottil et al. 2014; Hanchate et al. 2012). Following introduction of a new public insurance program for chronically ill, childless adults in Wisconsin, one study found a decrease in preventable hospitalizations (DeLeire et al. 2013), while another study examining the same program found that inpatient hospitalizations increased in a population of rural enrollees (Burns et al. 2014). Nikpay, Buchmueller, and Levy (2015) analyzed Medicare cost report data for Connecticut hospitals before and after the state's early expansion in 2010, finding an increase in Medicaid admissions and revenues. Baicker et al. (2013) used the Oregon Medicaid lottery to examine the effects of insurance coverage on health care use and outcomes. After approximately 2 years, Medicaid coverage generated no changes in hospital ED use or admissions. Following the 2012 California coverage expansion for childless adults through the Low Income Health Plan, there was a significant decline in use of inpatient and ED services (Lo et al. 2014). Another study analyzing the same coverage expansion in California concluded that the number of patients using self-pay and charity care decreased in for-profit hospitals, but nonprofit hospitals had no changes in payer mix (Bazzoli 2016).

Two published studies used multi-state hospital data to examine effects of the ACA coverage expansion in 2014. Nikpay, Buchmueller, and Levy (2016) analyzed HCUP SID data between 2011 and the first half of 2014. In states that expanded Medicaid, uninsured hospital admissions decreased sharply and Medicaid admissions increased sharply; nonexpansion states had no change in payer mix. The second study, using Medicare cost report data before and after 2014, found decreases in uninsured admissions and ED visits for all states, with more pronounced declines in Medicaid expansion states, whereas Medicaid admissions and visits increased only in expansion states (DeLeire, Joynt, and McDonald 2014).

Some of the dissimilarities in the results of these studies may be attributable to differences in methodologies or in the populations studied. Some studies treated hospital admissions as the observation unit of interest, with outcomes observed only for individuals who were hospitalized (Kolstad and Kowalski 2012; DeLeire et al. 2013; Ellimoottil et al. 2014; Bazzoli 2016; Nikpay, Buchmueller, and Levy 2016). The other studies took a population-based approach, either by combining admission data with population estimates of corresponding geographic areas or by sampling a cohort of insurance enrollees and comparing their admission claims with those from other coverage groups. Nonetheless, admission-based and population-based studies should reach similar findings about total admissions, and we note that there are differences in findings within each collection. Although individual state experiences give insight into the effects of health care reforms, generalization is limited and nationally representative studies are needed. The hospital data used for our study cover nearly all short-term acute care hospitals in a broad and geographically diverse set of states, thus providing a more national perspective on ACA effects on inpatient services.

METHODS

Study Sample

We obtained Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SID) from 2011 through 2014 for 20 states (U.S. Agency for Healthcare Research and Quality 2015a). Eleven of the states opted to implement the ACA Medicaid expansion (Arizona, California, Colorado, Hawaii, Iowa, Kentucky, Michigan, New Jersey, New York, Oregon, and Vermont) and nine did not (Florida, Indiana, Kansas, Missouri, Montana, South Dakota, Tennessee, Virginia, and Wisconsin). California, Colorado, and New Jersey expanded Medicaid eligibility for childless adults prior to the ACA expansion on January 1, 2014. HCUP databases are consistent with the definition of limited datasets under the Health Insurance Portability and Accountability Act Privacy Rule and contain no direct patient identifiers.

Medicaid expansion provisions of the ACA are expected to have the largest impact on adults aged 19–64 years, so we restricted this analysis to inpatients within that age range.[1]

States sometimes submit incomplete inpatient data to HCUP because of nonreporting hospitals. Although the admission volume attributable to nonreporting is small, we addressed this issue by identifying a cohort of consistently reporting hospitals within these 20 states that could be tracked over the duration of our study period. Hospitals in this cohort must have (1) reported admissions in each quarter (Q) during the time frame of this study (2011Q1–2014Q4) and (2) exhibited a “consistent” pattern of reporting (to exclude organizations that experienced structural changes during the reporting period, such as mergers, acquisitions, openings, or closures).[2] No additional selection criteria were imposed.

Expected Source of Payment

Each admission was assigned an expected source of payment (“payer”) using variables for the expected primary, secondary, and tertiary payer with the following hierarchy applied: Medicare, Medicaid, private insurance (if listed on any of the three variables), then no insurance (if the primary expected payer was self-pay or no charge). Certain source of payment codes (e.g., indigent care programs and the Indian Health Service) were re-categorized as uninsured (see Barrett et al. 2014).[3] Analyses were performed on three individual payer types—Medicaid, private insurance, and no insurance—and on all-payers combined, which included Medicare and all other insurance types (“all-payers”).

State, County, and Hospital Market Data

We used data from additional sources to control for external factors that could affect insurance coverage and hospital admission volume changes unrelated to the ACA. We obtained state-level population estimates from the Census Bureau (U.S. Census Bureau, 2015) and county-level unemployment rates from the Bureau of Labor Statistics (U.S. Department of Labor, 2015).

Study Design

We conducted a retrospective cohort study, with state-specific payer, age group, sex, and quarter categories as the unit of analysis. Because of the quasi-experimental design provided by state differences in the decision to expand Medicaid, we employed a difference-in-differences approach. For each outcome of interest, we estimated separate statistical models for all-payers, Medicaid, private insurance, and no insurance.

Outcome and Predictor Variables

Primary outcome variables included admission volumes overall, preventable admissions, referral-sensitive surgical admissions, length of stay, patient illness severity, and cost per admission.

For both preventable and referral-sensitive surgical admissions, insurance coverage and consequently access to primary care and outpatient services are believed to affect utilization rates. We used the Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicators (PQIs) to identify hospitalizations that are potentially preventable when adequate ambulatory care is available (U.S. Agency for Healthcare Research and Quality 2015c). Referral-sensitive surgeries are "high-cost procedures that are usually non-emergent where failure to obtain a referral to a surgeon can be a barrier to obtaining the procedure" (Billings 2003). Referral-sensitive surgery coding definitions were obtained from published literature and updated for ICD-9-CM changes (Billings et al. 1993).

Length of stay and estimated cost per diem outcomes measured resource use per admission.[4] Patient illness severity was measured through a cost-based case-mix index.[5]

Outcomes were aggregated to state, age group, sex, and quarter-year levels for each payment source. We included state unemployment rates and state population sizes as control variables to account for exogenous factors affecting hospital use not accounted for in the difference-in-differences research design.

Model Specifications

We compared expansion states with nonexpansion states before and after implementation of the ACA Medicaid expansion. Difference-in-differences models were used to isolate ACA Medicaid expansion effects, with the following specification equation:

$$y_{ist} = \exp\Bigg(\alpha + \gamma_i + \mu_s + \varphi_t + \theta_s l + \sum_{q=1}^{4} \tau_q \mathbf{1}\{s \text{ is Medicaid Expansion state}\}\mathbf{1}\{t \text{ is } 2014\ \mathrm{Q}_q\} + X_{ist}\beta\Bigg) + \varepsilon_{ist}$$

In the equation, i indexes demographic categories (age/sex), s indexes states, t indexes calendar year and quarter combinations, q indexes calendar quarters, and l represents the linear evolution of time relative to the baseline study period (the first quarter of 2011). Parameters include an intercept (α), demographic (γ_i), state (μ_s), and time (φ_t) fixed effects, state-specific time trends (θ_s), the effects associated with other regressors (β), and Medicaid expansion effects (τ_q). The term X_{ist} contains two additional time-varying state attributes: unemployment rates and population sizes. ε_{ist} is a mean-zero error term that is not correlated with the regressors but is potentially correlated across observations within states.

The outcomes (y_{ist}) are described in the preceding section. The linear predictor is mapped to the conditional mean of the outcome using an exponential function. All models were estimated using Poisson pseudo-maximum-likelihood (PPML) techniques (Santos Silva and Tenreyro 2006). The PPML estimator is applicable to non-negative response data even if the variable is theoretically continuous, and it yields consistent parameter estimates regardless of whether the dependent variable follows a Poisson distribution, so long as the conditional mean is properly specified. Furthermore, while PPML is most efficient when the conditional variance of the dependent variable is proportional to its conditional mean, the consistency properties of the estimator are retained even if this assumption is violated.

Outcomes conditional on admission (length of stay, patient illness severity, and cost) were modeled with the logarithm of admission volume included as an offset term in the regression model. The symbol τ_q represents the effect of state Medicaid expansion status on outcomes in quarter q of 2014. The identification of τ_q results from cross-state differences in within-state changes in outcomes, controlling for demographic group, time, and state–time interaction effects. The function $\exp(\tau_q)$ represents the ratio of the outcome variable for expansion states versus nonexpansion states in 2014 quarter q. Hence, exp $(\tau_q) - 1$ is the percentage change associated with Medicaid expansion.

The τ_q parameters, $q = 1,\ldots,4$, refer to quarters 1–4 of 2014 for all states in our study except Michigan, which had a delayed expansion opt-in (April 2014). For that state, τ_1 refers to 2014Q2, τ_2 refers to 2014Q3, and so forth.

Given the hierarchical structure of our data, with admissions occurring over time and nested within states, statistical inference based on the assumption that the error terms ε_{ist} for all observations are statistically independent may lead to underestimated standard errors. We used the percentile-t cluster bootstrap method to correct standard errors for intra-state correlation.[6] In addition, given the large number of parameters tested, we employed the Benjamin–Hochberg false discovery rate method assess the issue of inflated type 1 errors. Of those tests found significant in a research study, "the false discovery rate is the expected fraction of those tests in which the null hypothesis is true" (Glickman, Rao, and Shultz 2014). In this study, we have used a conventional statistical significance threshold of .05 to identify non-zero effects. Applying the Benjamin–Hochberg algorithm to the tests we conducted using this significance level, we calculate a maximum false discovery rate of .175.

Results

Descriptive Statistics

Table 1 contains the descriptive statistics for 1,002 nonexpansion state hospitals and 1,275 expansion state hospitals included in the study sample. There are notable differences in hospital characteristics by Medicaid expansion status. Nonexpansion state hospitals tended to be smaller and have for-profit ownership, whereas expansion state hospitals tended to be larger and have not-for-profit ownership. Expansion states had a higher percentage of teaching hospitals than nonexpansion states (28.1 and 18.3 percent, respectively) and were more likely to be in urban locations (73.4 and 62.9 percent, respectively).

Market and admission characteristics, aggregated by state expansion status and year for 2013 (before most states expanded Medicaid) and 2014, are presented in Table 2. Nonexpansion states had lower unemployment rates in

Table 1: Sample Descriptive Statistics for Hospital Characteristics, 2014

Hospital Characteristics	*Nonexpansion States (N = 9)*	*Expansion States (N = 11)*
Hospitals (*n*)	1,002	1,275
Beds (%)		
0–25	20.1	13.7
26–50	10.5	9.3
51–100	20.6	15.3
101–250	25.4	30.4
251–500	15.0	22.6
501–1,000	6.4	7.5
1,001+	2.0	1.2
Government, nonfederal control (%)	16.4	15.9
Voluntary, nonprofit control (%)	57.5	67.4
For-profit control (%)	26.1	16.7
Urban location (%)	62.9	73.4
Teaching status (%)	18.3	28.1

Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

Table 2: Sample Descriptive Statistics for Market and Admission Characteristics, 2013 and 2014

	Nonexpansion States (N = 9)		Expansion States (N = 11)	
Variable	*2013*	*2014*	*2013*	*2014*
Market Characteristics				
Unemployment rate (%)	6.9	5.9	8.2	6.8
Population annual growth rate (%)	0.7	0.7	0.7	0.7
Admission Characteristics				
Total admissions	3,277,592	3,297,431	5,236,687	5,218,153
Admissions per hospital (mean)	3,278	3,294	4,107	4,089
Patient illness severity (mean)	0.96	0.97	0.95	0.96
Total cost (mean $)	10,037	10,124	12,083	12,334
Length of stay (mean days)	4.4	4.5	4.6	4.6
Female (%)	60.2	60.2	60.9	61.0
Age (years, %)				
19–34	31.9	31.9	33.9	33.9
35–54	38.9	38.4	38.8	38.3
55–64	29.1	29.6	27.3	27.7
Expected source of payment (%)				
Medicaid	23.1	23.5	28.7	35.8
Medicare	18.4	18.8	14.3	14.3
Uninsured	13.3	12.2	10.5	5.0
Other	5.2	5.2	3.8	3.4
Private	40.0	40.4	42.7	41.6
Principal diagnosis (%)				
Asthma	1.5	1.5	1.0	1.0
Congestive heart failure	1.3	1.4	1.3	1.3
Chronic obstructive lung disease	0.9	0.9	0.9	0.9
Diabetes	2.1	2.2	2.0	2.0
Mental and/or substance use disorder	11.4	11.7	10.7	10.6
Referral-sensitive surgical admissions (%)	5.3	5.3	4.7	4.8
Preventable admissions (PQIs) (%)	8.5	8.5	7.5	7.4

PQI, Prevention Quality Indicator.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

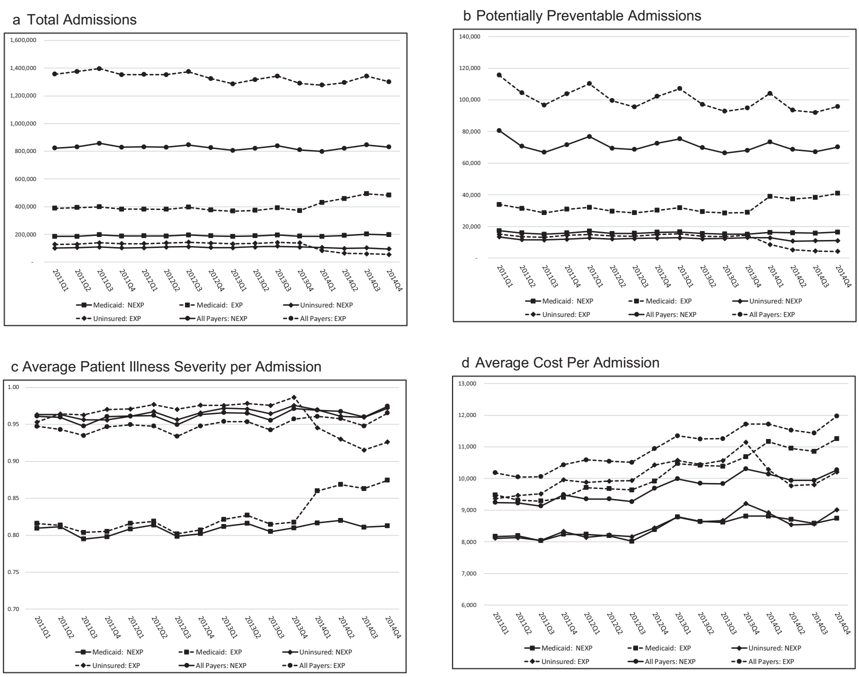
each year. In 2013, compared with nonexpansion states, expansion states had a larger mean hospital admission volume (4,107 vs. 3,278) and a higher mean hospital cost per admission ($12,083 vs. $10,037). Age, sex, and case-mix distributions were similar. Percentages of admissions were similar in the two expansion-status groups for those with principal diagnoses of asthma, COPD, CHF, diabetes, and mental and/or substance use disorder; and those admissions classified as preventable or referral-sensitive surgeries.

In 2013, the percentages of admissions by type of payer were nearly equivalent for nonexpansion and expansion states. However, in 2014, the percentage of uninsured admissions in expansion states declined markedly while the percentage of admissions with Medicaid increased.

Medicaid Expansion Effects on Hospital Admissions and Outcomes

Prior to 2014, descriptive data on admission volumes for expected payment sources (all-payers, Medicaid, no insurance, and private insurance) exhibited only minor quarterly fluctuations (Figure 1a). Total admission volume trends were similar for expansion and nonexpansion states during the 2011–2014 time period. Starting in 2014, following ACA implementation, there was a

Figure 1: Observed Trends for Selected Study Outcomes by State Medicaid Expansion Status and Payment Source, 2011–2014

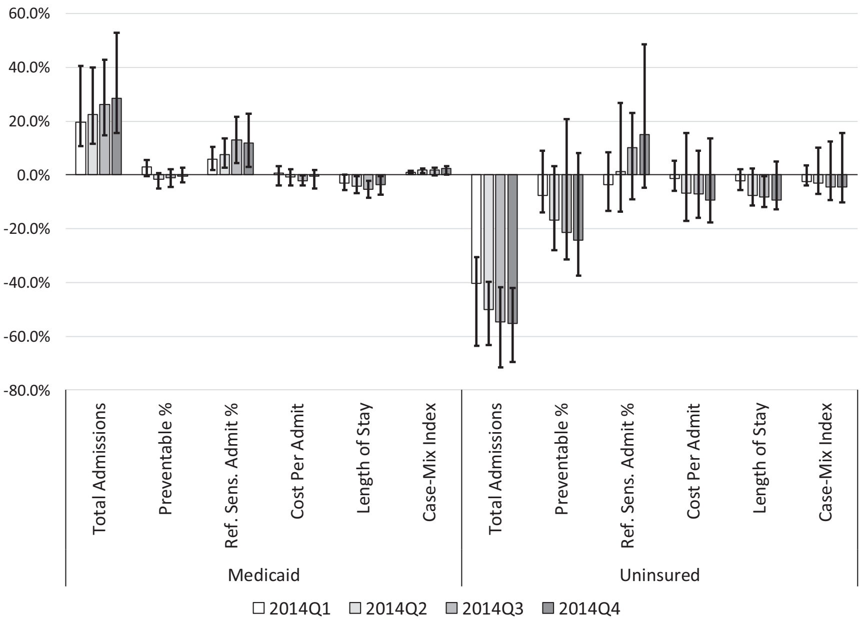


Abbreviations: Q, quarter, NEXP, nonexpansion State; EXP, Expansion State.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

sharp increase in Medicaid admissions and a corresponding decrease in uninsured admissions for expansion states. Similar patterns were observed for potentially preventable admissions (Figure 1b). Patient illness severity also experienced a sharp increase for Medicaid and decrease for the uninsured in expansion states in 2014 (Figure 1c). The average cost per admission exhibited a regular increase for Medicaid and all-payers between 2011 and 2014. For the uninsured, the average cost per admission declined notably starting in the first quarter of 2014 (Figure 1d).

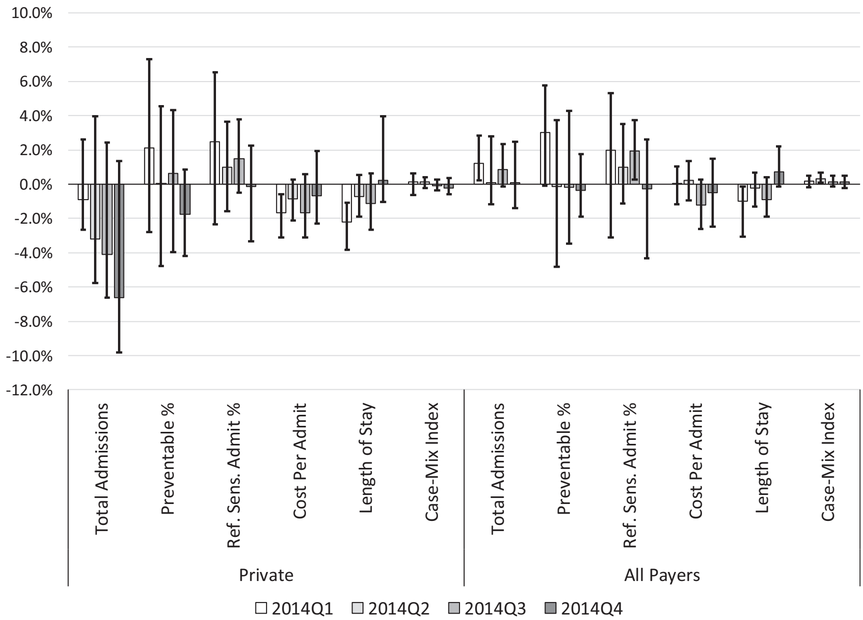
Figure 2 and 3 illustrate the percentage changes (*expansion effects*) associated with the Medicaid expansion coefficients estimated under our difference-in-differences framework. The expansion effects are interpreted as the differences in post-ACA changes between expansion and nonexpansion states. Figure 2 shows the quarterly expansion effects during 2014 for the Medicaid and

Figure 2: Expansion Effects for Study Outcomes: Medicaid and Uninsured, 2014, Quarters 1–4



Note. Error bars represent 95% confidence intervals for expansion effects.
Abbreviations: Q, quarter; Ref. Sens., Referral-Sensitive Surgery; Admit, Admission.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

Figure 3: Expansion Effects for Study Outcomes: Private and All-Payers, 2014, Quarters 1–4



Note. Error bars represent 95% confidence intervals for expansion effects.
Abbreviations: Q, quarter; Ref. Sens., Referral-Sensitive Surgery; Admit, Admission.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

the uninsured, whereas Figure 3 provides the similar information for private insurance and all-payer admission groups. The error bars represent 95% confidence intervals for the expansion effects. Tables 3 and 4 contain the expansion effects, 95% confidence limits, and *p* values for all outcomes in the figures. Confidence intervals and *p* values were computed using the percentile-t methodology described above to address clustering at the state level.

Total admission volumes had large positive expansion effects for Medicaid and negative effects for the uninsured (Figure 2); expansion effects for the privately insured also were negative (Figure 3) but failed to achieve statistical significance ($p > .05$). For all-payers, there was only one-quarter with small positive admission volume expansion effects ($p > .05$, Figure 3). Both the positive and negative expansion effects for Medicaid and uninsured admission volumes tended to increase in magnitude over time. In 2014Q4, compared with nonexpansion states, expansion states experienced a 28.5 percent increase in Medicaid admissions, a 55.1 percent decrease in uninsured admissions, a nonsignificant decrease in 6.6 percent in privately insured admissions, and a nonsignificant 0.1 percent increase in total admissions (Tables 3 and 4).

The ACA was associated with increases in the proportion of referral-sensitive surgical admissions for Medicaid ($p < .05$, Figure 2) in expansion states compared to those not expanding. No other significant effects for referral-sensitive surgical or preventable admissions were found. We found significant negative length of stay expansion effects in most quarters for Medicaid and the uninsured, whereas positive expansion effects for the Medicaid patient illness severity were significant in all quarters ($p < .05$, Table 3). The uninsured patient illness severity expansion effect was negative in all quarters by larger absolute amounts, but failed to achieve statistical significance (Table 3). There was one significant expansion effect for cost per admission: private insurance in 2014Q1 (Figure 3, Table 4).

Sensitivity analyses were conducted to assess the robustness of our estimates. Alternate statistical specifications involved omitting state-specific time trends and using only the pre-ACA time period to estimate state-specific time trends. California and New Jersey were dropped from the sample to determine whether their early Medicaid expansions had any impact on our results. We separately excluded Michigan (delayed Medicaid expansion) and Wisconsin (state-funded Medicaid expansion) from the study sample to assess sensitivity of our results to inclusion of these states. None of these sensitivity analyses materially changed the results presented above.

DISCUSSION

We hypothesized that admission volumes among adults aged 19–64 years would increase for Medicaid and all-payers and decline for the uninsured in Medicaid expansions states when compared to nonexpansion states. The results corroborated our hypotheses with respect to admissions for Medicaid and the uninsured. Although expansion effects for all-payer admission volumes were positive, only the effect for 2014Q1 was statistically significant and all were small compared with those for Medicaid and uninsured. The studies of Kolstad and Kowalski (2012); Nikpay, Buchmueller, and Levy (2015); and DeLeire, Joynt, and McDonald (2014) also found post-expansion increases in Medicaid admission volumes and decreases for the uninsured, but they did

Table 3: Medicaid Expansion Effect Models: Expansion Effect Estimates for Uninsured and Medicaid Admission Volumes and Outcomes

		Medicaid				Uninsured			
Outcomes	*Estimate*	*2014Q1*	*2014Q2*	*2014Q3*	*2014Q4*	*2014Q1*	*2014Q2*	*2014Q3*	*2014Q4*
Total admissions	Expansion effect (%)	19.5	22.5	26.3	28.5	−40.4	−50.0	−54.6	−55.1
	95% confidence limits (%)	(10.7, 40.6)	(11.5, 40.0)	(14.6, 42.7)	(15.4, 52.9)	(63.5, −30.6)	(63.2, −39.9)	(71.5, −41.8)	(69.4, −42.0)
	p value	.017	.007	.003	.006	.017	.001	.005	.001
Other Admission Characteristics									
Preventable admission percentage	Expansion effect (%)	2.9	−1.6	−1.1	−0.4	−7.6	−16.9	−21.3	−24.4
	95% confidence limits (%)	(−0.5, 5.6)	(−5.0, 0.7)	(−4.5, 2.0)	(−2.8, 2.6)	(−13.9, 8.9)	(−27.9, 3.3)	(−31.5, 20.8)	(−37.4, 8.0)
	p value	.065	.184	.455	.751	.213	.065	.158	.068
Referral-sensitive surgery admission percentage	Expansion effect (%)	5.7	7.4	13.0	11.8	−3.7	1.4	10.1	15.0
	95% confidence limits (%)	(1.9, 10.3)	(2.6, 13.4)	(4.5, 21.6)	(3.1, 22.8)	(−13.4, 8.3)	(−13.6, 26.6)	(−9.2, 23.0)	(−4.9, 48.6)
	p value	.011	.010	.006	.021	.436	.854	.167	.170
Total cost per admission	Expansion effect (%)	0.7	−0.8	−2.1	−0.5	−1.4	−6.7	−7.0	−9.2
	95% confidence limits (%)	(−3.8, 3.3)	(−4.0, 2.0)	(−4.0, −0.2)	(−5.0, 1.9)	(−5.9, 5.2)	(−17.1, 15.6)	(−16.0, 9.1)	(−17.6, 13.6)
	p value	.596	.557	.042	.738	.466	.230	.157	.128
Length of stay, days	Expansion effect (%)	−3.0	−4.3	−5.3	−3.5	−2.1	−7.6	−8.3	−9.3
	95% confidence limits (%)	(−5.5, 0.0)	(−6.9, −0.4)	(−8.5, −2.3)	(−7.3, −0.3)	(−5.8, 2.1)	(−11.3, 2.5)	(−11.9, −0.4)	(−12.7, 5.0)
	p value	.040	.020	.006	.053	.283	.039	.019	.039
Patient illness severity	Expansion effect (%)	1.0	1.8	1.8	2.3	−2.5	−3.2	−4.6	−4.6
	95% confidence limits (%)	(0.3, 1.5)	(0.6, 2.4)	(−0.1, 2.6)	(0.2, 3.1)	(−4.0, 3.6)	(−7.2, 10.3)	(−9.3, 12.3)	(−10.2, 15.7)
	p value	.004	.002	.031	.015	.344	.408	.382	.397

Note. Probability values and 95% confidence limits calculated using the t-percentile method; see Cameron and Miller (2015).
Q, quarter.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

Table 4: Medicaid Expansion Effect Models: Expansion Effect Estimates for Private Insurance and All-Payer Admission Volumes and Outcomes

		Private Insurance				*All-Payers*			
Outcome	*Estimate*	*2014Q1*	*2014Q2*	*2014Q3*	*2014Q4*	*2014Q1*	*2014Q2*	*2014Q3*	*2014Q4*
Total admissions	Expansion effect (%)	−0.9	−3.2	−4.1	−6.6	1.2	0.1	0.8	0.1
	95% confidence limits (%)	(−2.7, 2.6)	(−5.8, 4.0)	(−6.6, 2.5)	(−9.8, 1.3)	(0.2, 2.9)	(−1.2, 2.8)	(−0.2, 2.3)	(−1.4, 2.5)
	p value	.442	.178	.116	.052	.079	.908	.183	.924
Other Admission Characteristics									
Preventable admission percentage	Expansion effect (%)	2.1	0.1	0.6	−1.8	3.0	−0.1	−0.2	−0.3
	95% confidence limits (%)	(−2.8, 7.3)	(−4.8, 4.6)	(−3.9, 4.3)	(−4.2, 0.9)	(−0.1, 5.8)	(−4.8, 3.8)	(−3.5, 4.3)	(−1.9, 1.7)
	p value	.331	.971	.725	.162	.040	.935	.922	.726
Referral-sensitive surgical admission percentage	Expansion effect (%)	2.5	1.0	1.5	−0.1	2.0	1.0	2.0	−0.3
	95% confidence limits (%)	(−2.4, 6.5)	(−1.6, 3.7)	(−0.5, 3.8)	(−3.3, 2.2)	(−3.1, 5.3)	(−1.1, 3.5)	(0.3, 3.7)	(−4.3, 2.6)
	p value	.218	.399	.149	.910	.282	.349	.031	.851
Total cost per admission	Expansion effect (%)	−1.6	−0.8	−1.6	−0.7	0.1	0.2	−1.2	−0.5
	95% confidence limits (%)	(−3.1, −0.6)	(−2.1, 0.3)	(−3.1, 0.6)	(−2.3, 1.9)	(−1.2, 1.0)	(−0.9, 1.3)	(−2.6, 0.3)	(−2.5, 1.5)
	p value	.016	.169	.076	.487	.927	.710	.095	.595
Length of stay, days	Expansion effect (%)	−2.2	−0.7	−1.1	0.2	−1.0	−0.2	−0.9	0.7
	95% confidence limits (%)	(−3.8, −1.1)	(−1.9, 0.5)	(−2.7, 0.6)	(−1.0, 4.0)	(−3.1, −0.1)	(−1.3, 0.7)	(−1.9, 0.4)	(−0.2, 2.2)
	p value	.005	.229	.181	.815	.191	.603	.110	.207
Patient illness severity	Expansion effect (%)	0.1	0.2	−0.1	−0.2	0.2	0.3	0.1	0.1
	95% confidence limits (%)	(−0.6, 0.6)	(−0.2, 0.4)	(−0.4, 0.3)	(−0.6, 0.4)	(−0.2, 0.5)	(0.1, 0.7)	(−0.1, 0.5)	(−0.2, 0.5)
	p value	.533	.304	.638	.296	.227	.026	.445	.483

Note. Probability values and 95% confidence limits calculated using the t-percentile method; see Cameron and Miller (2015).
Q, quarter.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID).

not analyze admission volumes for all-payers. Ellimoottil et al. (2014) found post-expansion increases in hospitalizations for discretionary surgery for all non-elderly adults, while we found no significant all-payer effects for referral-sensitive surgical admissions.

One possible explanation for the finding of little increase in all-payer admission volumes is that the incremental increase in insurance coverage associated with Medicaid expansion was too small to yield a detectable effect. Published estimates from the 2014 National Health Interview Survey indicate that the uninsured population among adults aged 18–64 years declined by 5.1 percentage points in expansion states compared with 3.1 percentage points in nonexpansion states (Cohen and Martinez 2014). However, it is also possible that our estimates are close to zero because the Medicaid expansion did not increase inpatient utilization, as suggested by the Oregon Health Study (Baicker et al. 2013). Future studies using longitudinal data to identify newly insured individuals could help clarify whether there is a net effect of Medicaid expansion on all-payer admission volumes.

Expansion effects on admissions covered by private insurance were negative although not statistically significant and much smaller in magnitude than those for Medicaid or the uninsured. This partly reflects the fact that private insurance is the most common source of payment and that our expansion effects are expressed as percent changes. If we rescale the expansion effects by the pre-expansion (2013) share of admissions by payer in expansion states, the expansion effect on private admissions is of the same order of magnitude as the expansion effect on Medicaid. The negative expansion effects we found for privately insured admission volumes could be due to declines in private insurance enrollment or utilization rates for expansion compared to nonexpansion states. The population covered by individual and employer-sponsored plans grew in both expansion and nonexpansion states (Table S2 in Appendix SA2); the negative expansion effects may be due to smaller increases in expansion states, resulting in negative coefficient estimates (i.e., expansion effects) from the difference-in-differences design, assuming utilization rates remained constant. The interpretation is also affected by the increase in private coverage in nonexpansion states via the Health Insurance Exchanges, and these difference-in-difference findings are net of those effects. These findings do not necessarily imply that expanded Medicaid created a crowd-out of private insurance because other explanations cannot be ruled out. Changes in utilization among the privately insured could lead to changes in the outcomes studied here. Additionally, individuals in a broader income range qualified for marketplace subsidies in nonexpansion states than in expansion states—a possible explanation of the larger private insurance enrollment growth in nonexpansion states.

We also examined whether expansion caused particular types of inpatient admissions to increase or decrease at a faster rate than the total across all-payers. Our hypotheses were that, among all-payer admissions, the share of referral-sensitive surgical admissions would rise and the share of preventable admissions would fall. These hypotheses were based on the premises that health insurance coverage lowers out-of-pocket costs and helps meet "pent-up" demand for services among the uninsured population, at least in the short term. However, all-payer expansion effect point estimates for referral-sensitive surgical admission percentages were small and insignificant. We did find significant positive expansion effects for Medicaid referral-sensitive surgical admission percentages, which supports the pent-up demand hypothesis. Expansion effects for preventable admission percentages were large and negative for the uninsured although the effects were not statistically significant.

We tested several hypotheses regarding illness severity and resource use. They were based on the assumption that individuals acquiring coverage initially would have greater needs for inpatient services than those remaining uninsured. This assumption suggests that expansion effects for the uninsured should be negative for cost, length of stay, and patient illness severity (as measured by the case-mix index). For the uninsured, all expansion effects for cost, length of stay, and patient illness severity were negative, consistent with our hypotheses, but none were statistically significant. Large standard errors estimated for these effects may be due to state-level heterogeneity. Our models do not take into account the "starting point" for each state that expanded Medicaid. Some states had Medicaid income eligibility policies that were as generous or more generous than the ACA standards prior to 2014, whereas others had very low income thresholds. This may contribute to a high degree of variability in the expansion state hospital service use changes pre- and post-ACA. Negative uninsured expansion effects for those with greater hospital care needs are reinforced by analysis of chronic condition admission volumes, reported in Tables S1a, S1b and Figures S1a, S1b in Appendix SA2. In these results, there are many large and significant negative uninsured expansion effects for conditions such as asthma, congestive heart failure, chronic obstructive pulmonary disease, diabetes, and mental/behavioral health.

The results for uninsured, Medicaid, and privately insured admissions suggest that individuals with no insurance who were in greater need of hospital inpatient services were more likely than other individuals without insurance to gain Medicaid coverage in states that expanded Medicaid. Our findings are not sufficient to draw definitive conclusions about the mechanisms through which the Medicaid expansion has affected admissions because we cannot assess the relative importance of risk selection, population health, pent-up demand, and changes in out-of-pocket prices for hospital care.

Medicaid expansion did not affect the out-of-pocket price of care for those remaining uninsured, so we assume that changes in the composition of uninsured admissions primarily were due to changes in the composition of the uninsured population induced by take-up of the coverage expansions. It appears plausible to assume that changes in the post-ACA uninsured population are primarily due to previously uninsured individuals who gained coverage. In support of this assumption, Carman, Eibner, and Paddock (2015) found that 77 percent of adults uninsured in 2015 also were uninsured in 2013, whereas 23 percent dropped some form of coverage to become uninsured.

In contrast, changes in the composition of Medicaid or privately insured admissions are more difficult to interpret because acquisition of insurance may affect utilization. Furthermore, we cannot assume that newly insured individuals who adopt coverage because of Medicaid expansion all enrolled in Medicaid because other policy or economic changes including the Health Insurance Exchanges may have led some of these individuals to gain insurance through private coverage or to drop private coverage in favor of Medicaid. In short, we consider changes in the composition of uninsured admissions to be driven primarily by selective insurance take-up. However, changes in the composition of Medicaid or privately covered admissions may reflect not only selection, but also the price of hospital care, preventive care, and coverage transitions from other insurance types.

Our unit of analysis is admissions among demographic groups within states; we do not track individuals. This study design uses admission-level outcomes and cannot clearly distinguish effects of health insurance acquisition on lowering prices for services and selective take-up of insurance. Our estimates of effects on total admissions should be comparable to population-based estimates, but our findings of changes in the rate of particular types of hospitalizations (e.g., preventable) are not directly comparable to population-based estimates.

Measurement of preventable and referral-sensitive surgical admissions is challenging; this should be kept in mind when interpreting our results. Preventable admissions, as measured by the AHRQ prevention quality indicators, have been evaluated from a validity perspective and limitations have been pointed out (Agency for Healthcare Research and Quality, 2001b; Davies et al. 2011). One could also disagree with the specific procedures included in the list of referral-sensitive surgeries (e.g., joint replacement, breast reconstruction, and pacemaker implant), which constitute a small proportion of overall inpatient admissions (Table 2).

Difference-in-differences (DID) designs rely on the assumption of parallel pre-intervention trends in treatment and control groups. We used state-specific trends in our models to address potential problems introduced by nonparallel trends. However, other approaches could be considered. Ryan, Burgess, and Dimick (2015) provide evidence that use of propensity score matching of controls to treatments can reduce bias in DID studies when treatment effects are correlated with pre-intervention levels or trends. While attractive, matching controls would be problematic in our study, where the number of treatment and control observations is small (11 expansion and 9 nonexpansion states).

CONCLUSION

Medicaid expansion did not appear to change all-payer admission volumes. Medicaid expansions were associated with increased Medicaid and decreased uninsured admission volumes. Our results are consistent with the hypothesis that those previously uninsured with greater needs for inpatient services were most likely to gain coverage. In that case, compositional changes in uninsured and Medicaid admissions (e.g., measured by cost, length of stay, patient illness severity, or proportions of chronic conditions) may be driven by selection.

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Disclaimer: None.

NOTES

1. Based on the authors' analysis of American Community Survey data between 2013 and 2014, the number of uninsured decreased substantially for both children and adults. Our decision to focus on adults is based on the much larger size of the adult uninsured population and higher hospital utilization rates.
2. The consistency measure for each hospital was the maximum absolute percentage deviation (over quarters) of total quarterly admissions as a percentage of the mean admission volume for the entire hospital quarterly series. After applying the consistency criterion and the requirement of data present in all quarters, we excluded 6.1 percent of hospitals and 5.3 percent of admissions in the 20-state sample.
3. HCUP expected source of payment standard values were Medicaid, Medicare, Private Insurance, No Charge, Self-Pay, and Other. No Charge and Self-Pay were reclassified as uninsured. There is an unknown amount of error in the expected source of payment codes assigned by hospitals to patient admission records that need to be considered when interpreting our results (Buchmueller, Allen, and Wright 2003; Chattopadhyay and Bindman 2005).
4. Costs were estimated using the cost-to-charge ratio method (U.S. Agency for Healthcare Research and Quality, 2015d).
5. We developed the case-mix index using 2013 HCUP SID data from all available states. Each admission record was assigned a CCS principal diagnosis category and estimated cost (U.S. Agency for Healthcare Research and Quality 2015b). The case-mix index for each diagnosis category was computed as the ratio of its average cost to the average cost for all diagnosis categories.
6. The *SAS* GENMOD procedure was used to fit the models (SAS Institute, 2015). Parameter confidence intervals and p values were calculated using the percentile-t cluster bootstrap method (see Cameron and Miller 2015).

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Supporting Information

Additional supporting information may be found online in the supporting information tab for this article:

Appendix SA1: Author Matrix.
Appendix SA2: Additional Expansion Effect Estimates.
Table S1a. Medicaid Expansion Effects for Chronic Conditions:

Medicaid and Uninsured, 2014, Quarters 1–4.

Table S1b. Medicaid Expansion Effects for Chronic Conditions: Private Insurance and All-Payers, 2014, Quarters 1–4.

Table S2. Percent Change in Population by Insurance Coverage and State Medicaid Expansion Status.

Figure S1a. Medicaid Expansion Effects for Chronic Conditions: Medicaid and Uninsured, 2014, Quarters 1–4.

Figure S1b. Medicaid Expansion Effects for Chronic Conditions: Private Insurance and All-Payers, 2014, Quarters 1–4.